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# Charcoal Rot of Plants in East Texas

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## Preface

Charcoal rot is caused by a fungus named *Macrophomina phaseoli* that has been reported in at least 284 species of plants. These include corn, sorghum, cowpea, bean, lima bean, crotalaria, soybean, pepper, tomato, cotton, sweet potato, watermelon, cantaloupe, squash, pumpkin, radish, turnip and cabbage in Texas.

The main symptom of charcoal rot is shredding of the tissues of the stems and the charcoal-like appearance due to the minute black sclerotia of the causal fungus under the bark, in the pith and in the woody tissues. Twelve host plants had gray discoloration of the stem bark, and seven hosts had fruits destroyed by charcoal rot.

Charcoal rot of corn was severe in 4 seasons when the total rainfall in June, July and August was only 3 to 6 inches, but was mild in 2 seasons when the total rainfall in these 3 months was 19 and 20 inches.

This apparently is the first report of charcoal rot of cabbage, *Heterotheca*, *Sesbania macrocarpa*, and of Giant Striated crotalaria; and the occurrence of the spore stage of the causal fungus in watermelon and Irish potato.

Methods of culture that invigorate crop plants apparently increase their resistance to charcoal rot. Resistant varieties of some crops help to control charcoal rot. Crops that have their seedling stages and those that mature in cool, rainy weather are unlikely to be damaged by charcoal rot during such weather. Adequate rain or irrigation water in the latter part of the growing season practically controls charcoal rot of sorghum.

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# Charcoal Rot of Plants in East Texas

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THE charcoal rot disease of plants was discovered by Halsted in 1894 (69). It has been found in many parts of the United States, especially in the southern half of this country. Damage by charcoal rot, especially to sorghum, corn and legumes, has stimulated much research work on the cause and control of this disease.

The purpose of this bulletin is to describe the parasite that causes charcoal rot, the associated environmental conditions, the symptoms of charcoal rot in farm crops and other plants in Texas, and discuss the parasitism and control of the causal fungus.

## DESCRIPTION OF THE CAUSAL FUNGUS

Charcoal rot of plants is caused by *Macrophomina phaseoli* (Maublanc) Ashby. The pycnidia are black, more or less erumpent, globose or depressed, and 100 to 216 microns in diameter (6); they have no stroma. The ostiole is small and truncate. The conidiophores are simple, rod-shaped and 10 to 15 microns long; they are hyaline and non-septate. The pycnosporos are hyaline, one-celled, elliptical, about 3 times as long as wide, and range in sizes from 12 to 34 by 6 to 12 microns (42, 24). The sclerotia are smooth, black, hard, usually shiny and range in sizes from 27 to 200 microns in diameter (71, 24, 6). This fungus causes seedling blight, stem rot, root rot and fruit rot of at least 284 species of plants in many parts of the world.

## NAME OF THE DISEASE AND ITS CAUSAL FUNGUS

From two common names of the disease and three or more technical names for the causal fungus, it is helpful to select one name for the disease and one for its causal fungus. Black sclerotia that blacken tissues are the only reproductive bodies that have been found in most hosts. They were named *Sclerotium bataticola* Taub. or *Rhizoctonia bataticola* (Taub.) Butler. However, a name for the spore stage is preferred. Hence, when Ashby (6) found pycnidia and spores and proved that they are the same fungus as the sclerotia, he described *Macrophomina phaseoli* as the name of the spore stage of the fungus, and listed several synonyms. However, the oldest name of this fungus is *Macrophoma phaseoli* Maublanc (46). Ashby changed the genus name to *Macrophomina* because Petrak (54) described it as a *Phoma* without a stroma, but this does not distinguish it from many other species of *Phoma* and *Macrophoma* (83, 65, 13).

Frequent change in the names of well-known organisms is confusing. Hence, the policy of *nomina conservanda* is used to retain the name, *Macrophomina phaseoli* (Maubl.) Ashby, as the cause of charcoal rot (89). The spore stage occurs mainly in jute and legume stems, in which the disease has been named ashy stem blight due to the gray discoloration of the bark. However, the sclerotial stage is more common so charcoal rot is the preferred common name of the disease.

#### SUBSPECIES OF *MACROPHOMINA PHASEOLI*

Reichert and Hellinger (60) described the following subspecies:

*Sclerotium bataticola* ssp. *typica*: This contains the isolates from bean, eggplant, pumpkin, potato, pepper and *Cicer*. In culture, it has a rapid growth of fine, nonpersistent mycelium, and a nearly even distribution of smooth, round sclerotia. Barrel-shaped cells and fumaceous hyphae are uncommon. The tomato isolate produced pink color, while the *Cicer* isolate produced yellow color. Except in the pepper isolate, the sclerotia form by the fusion of barrel-shaped cells. The pepper isolate is a variety with sclerotium formation by fusion of barrel-shaped cells from one hypha with ordinary cells from another hypha. The isolates from bean and pumpkin were very virulent, whereas those from tomato and pepper were mildly virulent at 15 to 33° C.

*S. bataticola* ssp. *intermedia*: This subspecies includes the isolates from cotton and tobacco that are parasitic to bean. It is characterized by prominent, non-uniform, often patchy, persistent, fumaceous aerial mycelium. Mycelial growth is relatively slow and sclerotia are irregularly distributed. The sclerotia are rounded, irregular or elongate. The tobacco isolate produced a red-brown color in culture. The isolates from cotton and tobacco were virulent in the inoculation tests.

*S. bataticola* ssp. *sesamica*: This is the isolate from sesame that is nonpathogenic to bean. It is characterized by dense, uniform, persistent, fumaceous aerial mycelium in concentric zones, with abundant barrel-shaped cells. Mycelial growth is relatively slow in culture and sclerotia are irregularly distributed. It produced its sclerotia from the ordinary cells of one or two hyphae, and produced a dark yellow color in culture. The sclerotia were mostly irregular and occurred in masses.

In addition to these subspecies, *M. phaseoli* has several physiologic races that are noted with their hosts (40) in the following pages. The Taubenhause strain of *M. phaseoli* did not form pycnidia in jute.

#### REVIEW OF INFECTION EXPERIMENTS

*M. phaseoli* rotted sweet potatoes in 3 to 8 weeks (69). Martin (45) proved the pathogenicity of *M. phaseoli* in causing pepper fruit rot. Ashby (6) proved the identity of *M. phaseoli*

and *S. bataticola*. Virulent cultures of *M. phaseoli* killed young seedlings and injured older plants (11). Single-spore cultures of *M. phaseoli* always produced sclerotia (24, 26). Hildebrand, et al., (24) inoculated corn and soybean with an isolate of *M. phaseoli* from cotton that grew in Texas, and an isolate from soybean that grew in Ontario; these were distinct varieties and were strongly parasitic at 82 to 92° F. They proved the identity of *M. phaseoli* and *S. bataticola* in soybean. Pathogenicity of cultures decreased in about one month. This fungus grows between the cells of sorghum roots (40).

One variety of *M. phaseoli* produced spores in cultures (42). Suspensions of pycnospores were dried on unwounded bean stems and incubated in a moist chamber. Diseased spots appeared within 2 weeks and killed the stems. Parasites may attack plants through the natural wounds that are made by emerging secondary roots (33).

#### PHYSIOLOGY OF PARASITISM

Seedling blight of sorghum was worst at 106° F. but charcoal rot of the stalks was worst at 100° F. (40, 41). In dry soil, seedling blight was worst at 93 and 98° F., but in wet soil, seedling blight was worst at 77 and 82° F. Competition with other organisms in field soils apparently helps to minimize seedling blight of sorghum by *M. phaseoli* (14, 40, 42a, 63).

Summer weather in Texas is hot and dry most of the time; such weather is beneficial in maturing and harvesting grains and fruits. With the aid of occasional rains that generally prevent drouth-killing of plants, adapted varieties of crops endure hot drouths well and produce fair yields when pests do not damage them. *M. phaseoli* is most strongly parasitic in hot weather. Extensive killing of bean seedlings by charcoal rot occurred at temperatures of 80 to 106° F. (34). Hot drouth was unusually severe in 1948 when charcoal rot of radish, turnip and cabbage was found at Jacksonville. Although the heads of cabbage and the bulbous taproots of the radish and turnip usually grow best in cool weather, their seed crops often grow in hot weather.

Charcoal rot of corn and sorghum stalks usually does not become severe until they begin to mature (40, 41). *M. phaseoli* is a vigorous parasite in killing seedlings and blackening and killing branch roots, but it causes stalk rot especially in plants that are becoming senescent. Annual plants typically become senescent as they mature their crops, and charcoal rot may then injure them seriously. Weather that is too hot or dry for best growth of plants apparently increases their susceptibility to *M. phaseoli*. The sclerotia and spores of *M. phaseoli* are small dust-like particles and can be disseminated by wind.

It has been suspected that *M. phaseoli* may grow on non-living materials in soils (27), but neither local observations nor a review of literature gave any evidence to support this opinion.



Sclerotia of *M. phaseoli* were found by the writer only in the over-wintered corn stalks that it had killed. *M. phaseoli* was not one of the saprophytes that the writer found on corn stalks that remained in fields 6 months or longer after the crop ripened.

### PARASITOLOGY OF *M. PHASEOLI*

A redefinition of the term, parasite, facilitates understanding of the parasitism of *M. phaseoli*. A parasite is an organism that lives in or attached to another species of living organism from which it secures part or all of its food, water or minerals (84, 66, 14). The pathogenic kinds of parasites cause visible or measurable symptoms in the hosts. Environmental conditions commonly influence the severity of parasitic diseases. Many kinds of parasites are more destructive than *M. phaseoli*, but this pathogenic fungus causes serious damage to some crops under favorable conditions. The worst plant diseases such as black stem rust and late blight vary in destructiveness from slight to disastrous depending on abundance of inoculum and weather that favors or hinders the causal parasites.

### CHARCOAL ROT IN IMPORTANT EAST TEXAS PLANTS

#### Corn (*Zea mays*)

Charcoal rot decreases corn yields in East Texas each year. It occurred in epidemic proportions in 1944 and 1948 (89, 4). It was also serious in other states (51, 11, 73; Table 2).

Charcoal rot of corn is illustrated in Figure 1 and literature references (40, 41, 43). *M. phaseoli* causes a black root rot and seedling blight of corn (40). It kills the roots and dwarfs the seedlings of many crop plants, especially at 77 to 92° F. (63). When corn is ripening or ripe, charcoal rot is recognized easily by stripping off the leaf sheaths from the bases of the stalks and cutting diagonally through the crowns (89). Those with charcoal rot are more or less hollow and retted or shredded and are gray or black, due to the numerous black sclerotia in the pith and on the bundles of tracheae (Figure 1). Sclerotia were found in the pith of a few green corn stalks. The sclerotia usually were found in the lowest 1 to 18 inches of the stalks, but an ear of corn showed numerous sclerotia in pith of the cob and also in many of the kernels (Figure 2). The sclerotia occurred among the starch grains and made these kernels look gray or black. Numerous sclerotia bulged under the epidermis of these kernels. Nearly one-fourth of the corn stalks with charcoal rot near Jacksonville had gray epidermis as one symptom (Figure 1, C). Many of the largest roots were hollow and contained sclerotia.

Most of the plants of *Crotalaria spectabilis* died of charcoal rot in the hot drouth of 1943 in one field at Jacksonville. This field was used the next 5 years to test the resistance of crop plants to charcoal rot. Charcoal rot killed all of the plants of Ioana sweet corn in 1944, while Texas 12 showed 79 percent of

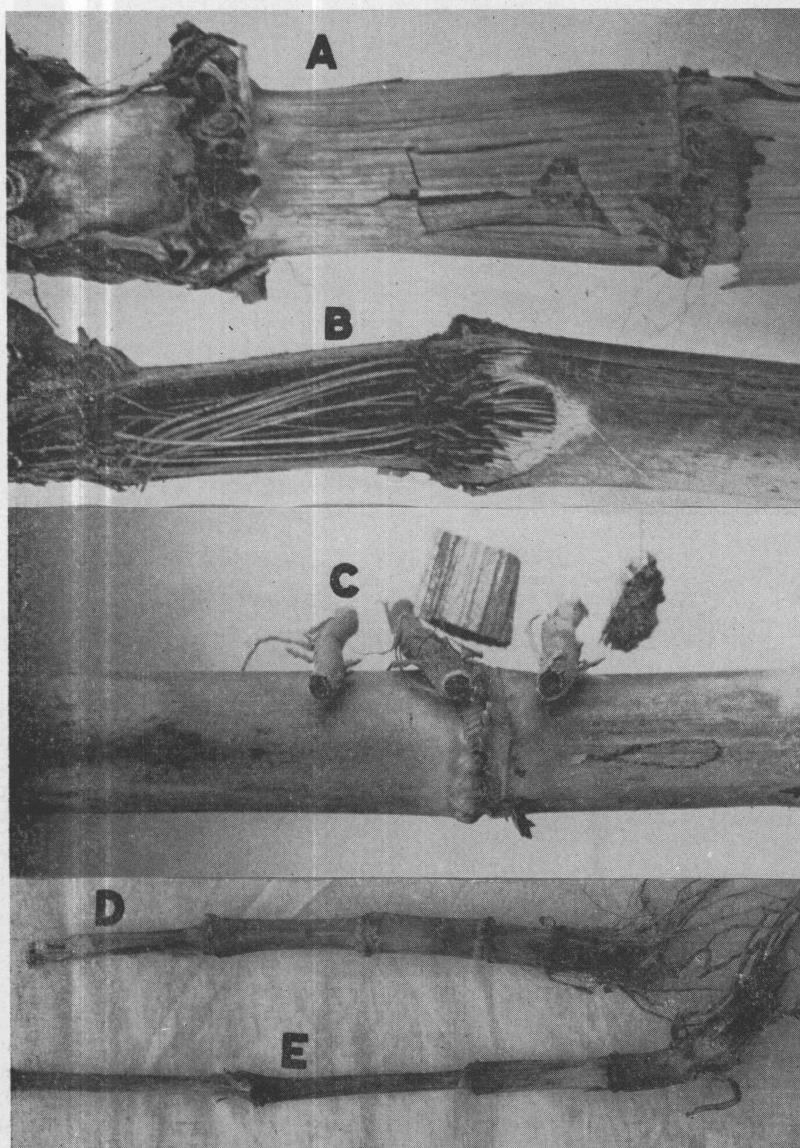


Figure 1. A to C are Yellow Dent corn; D and E are Ioana sweet corn with charcoal rot. A: Cracked, gray epidermis, and dark gray discoloration below epidermis and in branch roots due to many sclerotia. B: Crown of stem that has been retted and hollowed by charcoal rot, and blackened by sclerotia. C: Charcoal rot with gray epidermis of stem that is dotted with black sclerotia, except the left end that has ordinary straw-yellow color. Pieces of 3 hollow roots and 2 pieces of pith are gray or black with sclerotia. D: Interior of crown was retted and blackened. E: The symptom of extremely slender internode sometimes was associated with charcoal rot; also shown in picture D.

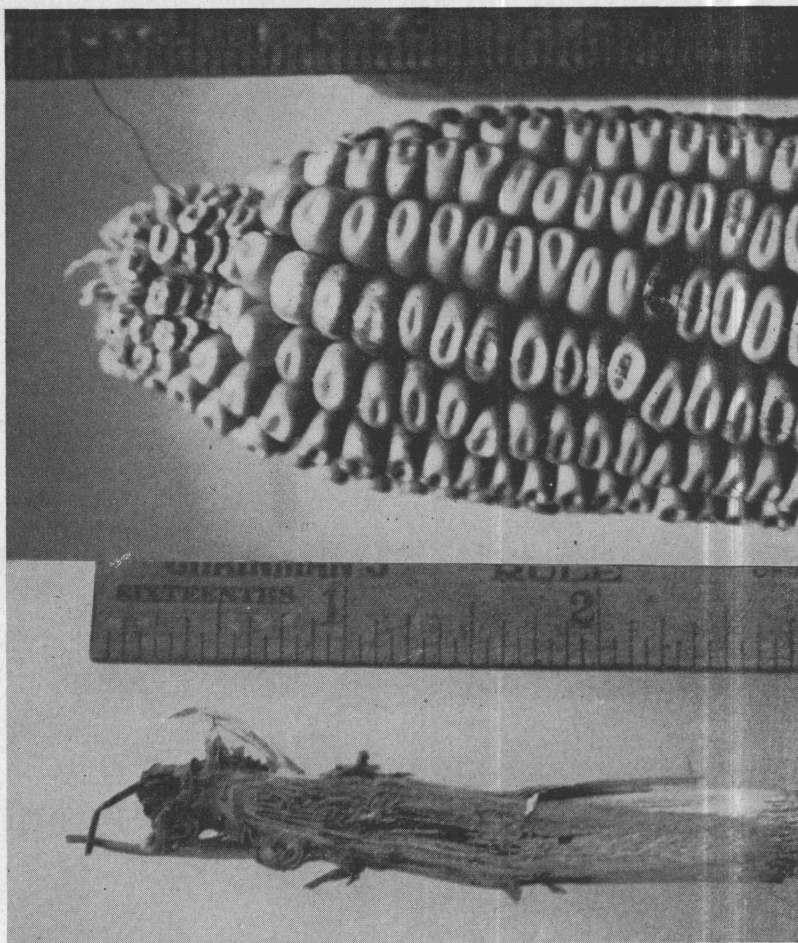


Figure 2. Upper picture: An ear of Yellow Dent corn with 41 black or gray kernels containing the sclerotia of *M. phaseoli*. Sclerotia also are abundant in the pith of the cob of this ear. Nearly three-fourths of the corn plants had charcoal rot in this part of the field. Lower picture: Crown of a sorghum stalk with the interior partly shredded and blackened with the sclerotia of *M. phaseoli*.

the plants with severe charcoal rot and 21 percent of the stalks with moderate charcoal rot. Yellow Dent showed 55 percent of the stalks with severe charcoal rot and 45 percent with moderate charcoal rot; the yield and quality of the ears were poor. Three fields of Texas 12 yielded only 8 bushels per acre. Lodging usually is rare in thin stands of corn in East Texas.

Livingston (40) correlated temperature and rainfall with severity of charcoal rot. When the average air temperature in summer was below 73° F. and rain exceeded 10 inches in July to September, charcoal rot was not very serious, but this disease was destructive in the regions with warmer or drier weather.



At Jacksonville maximum daily temperatures in the summer usually range from 85 to 103° F. (average about 90° F.). Most nights are uncomfortably warm, so the temperature is presumed to favor *M. phaseoli*. Charcoal rot was very destructive in 1943, 1944, 1947 and 1948 when the rainfall in June, July and August totaled 3.07, 5.25, 6.39, and 4.41 inches, respectively. In contrast, charcoal rot was not severe in corn in 1945 and 1946 when the rainfall in June, July and August totaled 20.32 and 19.16 inches, respectively. Early corn ripens in July and August near Jacksonville. The correlation of charcoal rot with rainfall resembles that in Nebraska (40, 41).

Enough water at the right time, while the corn is maturing, appears to be the best control for charcoal rot of corn stalks. Promising resistance occurs in some varieties (58) (Table 1). Resistance to charcoal rot appears to be increased by maintain-

Table 1. Resistance of corn varieties and hybrids to charcoal rot at Jacksonville.

Variety	Percentage of plants with charcoal rot*			
	1945	1946	1947	1948
Texas 18.....	8	12	39	32
Texas 12.....	23	4	80	40
Parents of Texas 12: KYS.....	35	.....	.....	.....
Parents of Texas 12: 127C.....	23	.....	.....	.....
Parents of Texas 12: 132A.....	18	.....	.....	.....
Parents of Texas 12: K4.....	13	.....	.....	.....
Texas 8.....	10	5	.....	.....
Texas 20.....	.....	2	63	**36
Texas 9W.....	.....	4	54	24
Texas 11W.....	.....	.....	63	15
Texas 7W.....	5	.....	.....	.....
Texas Golden Prolific.....	22	20	75	.....
Prolific Sur cropper.....	.....	.....	.....	27
Funk G711.....	13	.....	59	29
Funk G788.....	.....	.....	.....	47
Funk G716.....	17	9	.....	.....
DeKalb 1024.....	13	.....	.....	.....
DeKalb 1022.....	.....	6	.....	.....
United U79.....	27	.....	64	37
Ioana Sweet Corn.....	.....	.....	78	54
Reese Drought Resister.....	15	.....	50	.....
Ferguson's Yellow Dent.....	17	16	.....	.....
Surcropper.....	.....	16	.....	34
Iowealth TX1.....	.....	4	.....	.....
Mexican June.....	.....	.....	45	.....
Ohlahoma Yellow Dent.....	.....	.....	57	.....
Squaw (Gay).....	.....	.....	59	.....
Moler White.....	.....	.....	68	.....
Kreid Yellow Dent.....	.....	.....	.....	29
Golden June.....	.....	.....	.....	13
Dixie 11.....	.....	.....	.....	27

\*The soil was fertilized with 500 pounds of 5-10-5 fertilizer per acre. The corn was planted in replicated rows each year. Succulent growth of plants in rainy periods decreases their resistance to later droughts.

\*\*Texas 20 in 1948 showed charcoal rot in 66 percent of the 5,439 plants that were cut in representative rows in 4 fields of 1 acre each.

ing vigorous growth of the corn. This can be accomplished profitably in East Texas by plowing humus into the soil, mixing 300 pounds or more of 5-10-5 fertilizer per acre in the rows, planting in March, side dressing about 15 inches from both sides of the rows with 100 pounds of ammonium nitrate per acre when the corn is 6 to 12 inches tall, and controlling weeds.

### **Sorghum (*Sorghum vulgare*)**

The symptoms of charcoal rot of sorghum include damping-off of seedlings, black or brown cankers in the fibrous roots, retting and hollowing of the bases of the stems, blackening due to sclerotia (Figure 2), sclerotia on the vascular bundles, premature dying of the stalks, lodging of the stalks, decreased yields and inferior quality of the grain (40, 14a, 37). The mycelium of *M. phaseoli* was intercellular (40).

Many varieties of sorghum were tested at Jacksonville but none showed severe symptoms of charcoal rot. Some black, fibrous roots and crowns were found. The rains apparently were adequate to enable the drouth-resistant sorghum to avoid serious injury by charcoal rot. Darso and Chiltex varieties were very susceptible (14a, 89).

Seedling blight of sorghum by charcoal rot was worst at 93 to 108° F. but stalk rot was worst at 101° F. (40). Low soil moisture in the latter part of the growing season favored damage by charcoal rot.

Charcoal rot often is destructive to sorghum in the usual dry seasons in West Texas. Lodging of the stalks increases losses (19, 16, 17, 58, 59, 29, 30, 31). Varieties of sorghum generally are susceptible to charcoal rot (32). Midland has juicy stalks and a minimum amount of lodging. Promising resistance to charcoal rot was found in some varieties of sorghum (27, 40). Thick-stalked, leafy varieties showed least damage from charcoal rot (19). Thick stalks may give mechanical resistance to lodging.

A stalk rot of sorghum that sometimes is associated with charcoal rot in West Texas is caused by *Fusarium moniliforme* (75, 16).

Charcoal rot appeared to be worst in land that was continuously cropped in sorghum, and was practically controlled by adequate rain or irrigation water throughout the growing season (29, 31). The most damage occurred when abundant early season moisture was followed by drouth when the seed began to form. Lodging was severe in the milk stage of the grain.

Late planting of sorghum sometimes helps to minimize damage from charcoal rot probably because rainy and cool weather occur as the sorghum matures (32). However, late planting provides weather that may be hot enough to favor seedling blight unless rains invigorate the seedlings. Competing organisms in the soil may control *M. phaseoli*.

**Cowpea (*Vigna sinensis*)**

Cowpeas show both the charcoal rot and ashy-stem-blight symptoms that are caused by *M. phaseoli*, and produce both sclerotia and pycnidia in the same plants (Figure 3). The gray to white bark is more prominent in the blackeye than in the Purple Hull variety.

*M. phaseoli* killed the youngest leaves of cowpeas in rainy weather (79). The tips or outer halves of the leaves were light

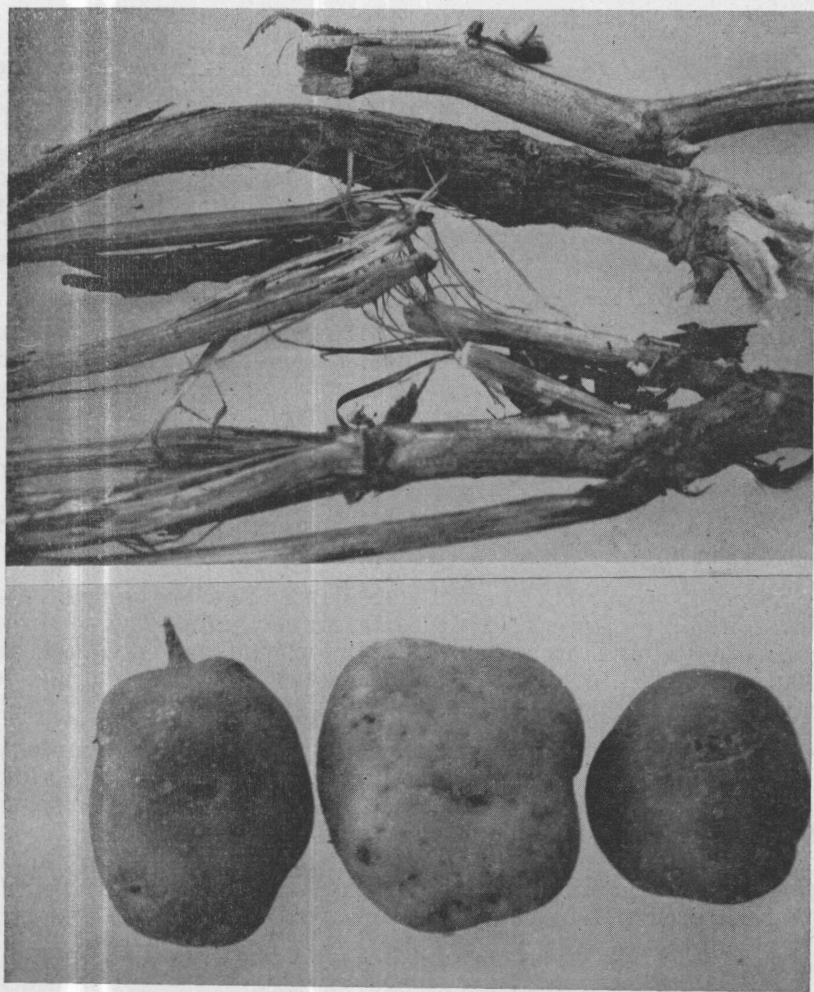


Figure 3. Top: Gray stem blight of blackeye peas caused by *M. phaseoli* with the black pycnidia protruding through the epidermis of two stems. The bark was rotted off the taproot, showing the woody surface that was blackened with sclerotia. Bottom: Irish Cobbler variety of potatoes showing a normal tuber in center. The other two tubers were blackened by *M. phaseoli*; the left tuber was blackened mainly near the eyes.

brown to gray and contained many pycnidia. The tissues were water-soaked at the margins of the dead spots.

Purple Hull and ordinary selections of blackeye varieties are very susceptible to *M. phaseoli* whereas the Iron, California No. 1 and Blackeye 8152 (California) varieties are resistant (85, 44). Tests at Jacksonville showed charcoal rot in only 6 percent of the plants of Blackeye 8152 in contrast with 55 percent of the plants with charcoal rot in the Purple Hull variety in 1943 (91).

#### Bean (*Phaseolus vulgaris*)

In beans and cowpeas, the sclerotia are abundant under the bark of the stems and taproots (Figure 4). *M. phaseoli* apparently grows abundantly in and near the cambium. Pinto, Yellow Wax and Stringless Greenpod varieties were very susceptible to charcoal rot at Jacksonville. Some bean plants also showed the pycnidia of *Phoma pampaena* Speg. in the bark of dead stems in 1944. Mycelium of *M. phaseoli* penetrated small bean roots and grew into the crowns (43). *M. phaseoli* attacks mature bean plants in fields (49).

Charcoal rot causes reddish-brown, often sunken spots in bean stems, and the centers of the spots become gray with sclerotia (21). Bean plants that become infected while they are young rarely bear seeds, and crop losses sometimes are large. *M. phaseoli* infected bean seedlings at the cotyledonary nodes and killed the hypocotyls but did not attack the roots (34). Rapid infection caused pre-emergence damping-off of the seedlings; subepidermal sclerotia in the hypocotyls caused the symptom of ashy stem blight.

Thirty-five pounds of beans were planted in a 1-acre field near Jacksonville on June 30, 1946 for a cannery crop. The soil was soaked by abundant rains 2 days later. Only about 100 bean plants emerged in this field and charcoal rot was the probable cause of the killing of the other seedlings in the very warm soil.

Dry brown spots without borders were the first symptoms caused by *M. phaseoli* in the tips of bean leaves (79). Pycnidia developed in the spots and the veins were red near the spots. The leaves were killed and the fungus sometimes grew from them into the stems. Pycnosporos from bean leaf spots produced typical sclerotia in culture. The bean leaf spots caused by *M. phaseoli* occurred in rainy summer weather.

#### *Crotalaria* spp.

*Crotalaria spectabilis*: Charcoal rot of crotalaria is identified by the decay of the bark on the taproot and base of the stem, dying of the plant and many black sclerotia under the bark (Figure 4). Charcoal rot also causes stem cankers (86). Most plants of the late variety died with charcoal rot in the hot drouths of 1943 and 1948. Reuter's early variety of crotalaria



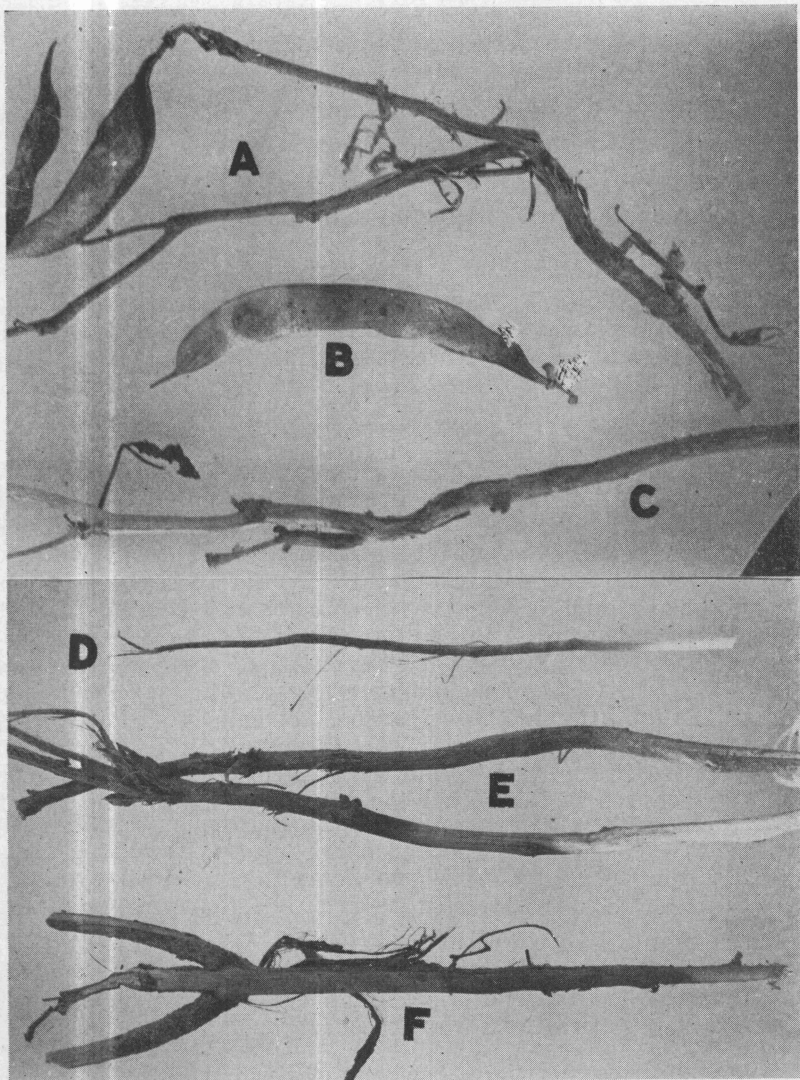


Figure 4. A and C: The ashy-stem-blight form of charcoal rot of the Pinto bean showing gray epidermis and retting of bark; B shows a gray pod that is dotted with many pycnidia. D: Charcoal rot of Hubam sweetclover showing white stem and black taproot. E: Charcoal rot of Bliss Triumph Irish potato showing white to gray parts of stems and black taproots with retting of bark. F: Charcoal rot of *Crotalaria spectabilis* showing retting of bark on stem and taproot, with the deeper tissues blackened with sclerotia.

resists charcoal rot (91). In the rainy seasons, the late variety outgrew weeds and made fine crops without cultivation (37a). However, in the dry seasons, competition with weeds decreased the growth of the crotalaria.

*Crotalaria mucronata* var. *Giant Striata* (47): This variety was very resistant to drouth and charcoal rot in fields in Smith and Cherokee counties in 1948.

*Crotalaria retusa*: This species did not show any symptom of charcoal rot in the rainy season of 1946.

*Crotalaria intermedia* (77): This species was very susceptible to charcoal rot in Smith county in 1948.

#### **Lima Bean (*Phaseolus lunatus*)**

Charcoal rot of lima beans was found in Texas in 1944 and 1948. Diseased plants showed retted taproots with sclerotia under the bark and in the pith cavity of stems. *M. phaseoli* was transmitted in lima bean seeds (5).

#### **Soybean (*Glycine max*)**

Sclerotia of *M. phaseoli* form under the bark of diseased soybean stems, and the plants die prematurely (24, 28). The first symptom was gray cankers that did not spread much until the plants became old. The variety of *M. phaseoli* from Ontario formed pycnidia, and also produced sclerotia in soybean stems to a height of 9 inches. The infections appeared about 3 months after the inoculations. Another variety of *M. phaseoli* was isolated from cotton that grew in Texas; it had smaller and more numerous sclerotia. Leopard spots were caused in soybean leaves, pods and stubble (Table 2). Charcoal rot caused serious losses in soybeans (35, 52, 53, 9, 41, 28). Charcoal rot in the Ogden variety of soybeans was found at Jacksonville in 1944. The sclerotia occurred in the retted bark of the stems to a height of 1 to 4 inches. Elongate sclerotia were in the wood of the stems.

#### **Sesbania macrocarpa**

In the rainy season of 1945 at Jacksonville 83 percent of the *Sesbania* plants had charcoal rot (Fig. 7, D). Sclerotia of *M. phaseoli* were found under the bark of the taproots, and pycnidia were found in the bark of a stem. This appears to be the first report of charcoal rot of *Sesbania macrocarpa*.

#### **Hubam sweetclover (*Melilotus alba* var. *annual*)**

Hubam sweetclover was damaged seriously by charcoal rot at Jacksonville (Figure 4, D). Sclerotia of *M. phaseoli* occurred under the bark of the taproots, and bulged under the epidermis of the gray parts of the stems (89).

#### **Velvet Bean (*Stizolobium deeringianum*)**

Plants of a vining variety of velvet beans did not show charcoal rot in 1944 except 5 plants from which gophers cut the taproots. These plants had retted crown tissues with sclerotia of *M. phaseoli* (89). This variety did not show any charcoal rot in 1945, but some of its plants showed charcoal rot in 1946. In 1948, 18 percent of the bunch variety of velvet beans had char-

coal rot with sclerotia under the bark and in the woody tissues of the taproots that showed some retting. The diseased tissues were black.

#### **Common Lespedeza (*Lespedeza striata*)**

A field of lespedeza near New Summerfield on October 29, 1946 showed all of the plants to be killed by charcoal rot with sclerotia under the bark of the stems. These plants had been mowed in hot, dry weather and the land had grown corn in 1934. No symptom of charcoal rot was found in the lespedeza plants that were growing in the adjacent pasture that had not been cultivated or mowed (91). This difference probably was due to the infestation of the soil with *M. phaseoli* from the corn crop, and weakening of the lespedeza by mowing in hot, dry weather.

#### **Peanut (*Arachis hypogaea*)**

*M. phaseoli* damages peanut roots, stems and seeds. This fungus was found in a runner variety of peanut with one kind of concealed damage to the nuts, and rots of the pegs and seeds (20, 81, 82, 5). The sclerotia occur in rotted taproots.

#### **Clover (Species of *Trifolium*)**

*M. phaseoli* blackens the roots of red clover and decreases its root system (22). It makes a reddish color in potato-culture media. *M. phaseoli* was found in seeds of subterranean clover (12).

#### **Tomato (*Lycopersicon esculentum*)**

*M. phaseoli* kills some tomato plants at Jacksonville each summer (89). Some otherwise green tomato plants show dead brown branches that have been killed by charcoal rot. Such stems have gray or brown bark, and are nearly hollow with many sclerotia on the interior wall and in the remains of the pith (Figure 5). Sclerotia also were found under the bark near the tops of the taproots; some of the tissues were retted. The spring crop of tomatoes in East Texas matures in June when the weather usually is rainy. Tomato plants with charcoal rot were found only in hot, dry weather in July to September. Commercial varieties of green-wrap tomatoes apparently resist charcoal rot. In 1946, Selection Y841 of yellow-fruited tomato showed 16 percent of the plants with charcoal rot in September, which indicates unusual susceptibility. A culture of *M. phaseoli* from tomato developed pycnosporos on snap-bean stems (42). Tomatoes were infected by artificial inoculation with *M. phaseoli* (45).

#### **Pepper (*Capsicum annum*)**

California Wonder variety of bell pepper plants showed serious wilting in the summers of 1944, 1947 and 1948 in Cherokee county (90). In most cases, the pathogen was evident only as elongate black sclerotia in the woody tissue in the bases of the taproots of wilting or dead plants (Figure 5) (69). Nearly

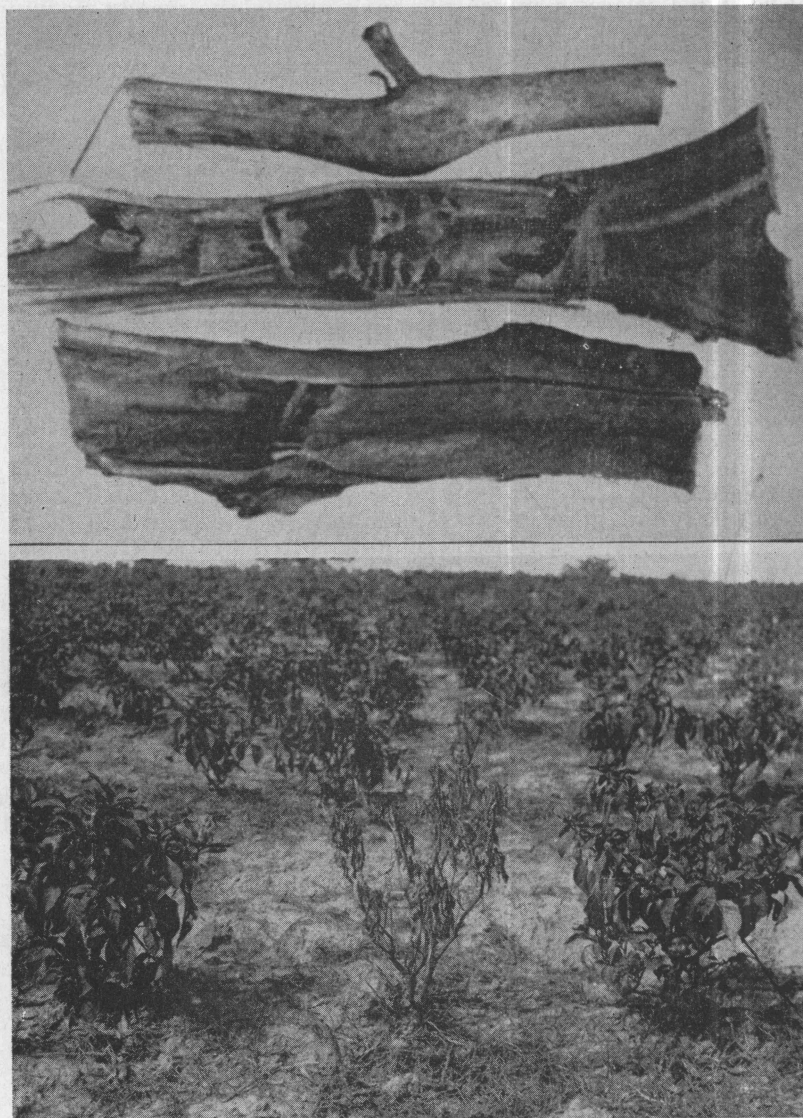


Figure 5. Top: Charcoal rot of tomato stems showing gray epidermis, hollow stems with interior blackened with sclerotia, and gray pith with sclerotia. Bottom: Plants of California Bell pepper that were normal except the center plant that was wilted by *M. phaseoli* with sclerotia in the wood in the base of the taproot.

spherical sclerotia were found in the pith of the bases of some dying branches on main stems. The symptoms ranged from slight wilting and drooping of the leaves to defoliation and browning of the stems. Pimento pepper plants did not show any charcoal rot when they grew beside California Wonder pepper



plants with serious charcoal rot in October 1948. Sclerotia occur under the bark of pepper stems (23). The pathogenicity of *M. phaseoli* in rotting pepper fruits was proved (45). The development of the sclerotia was traced. Experimental inoculations caused infections with *M. phaseoli* in pepper, sweet potato, tomato, cucumber, apple, eggplant and turnip, but not in carrot, parsnip nor red beet.

#### **Irish Potato (*Solanum tuberosum*)**

Black eyes or larger black areas characterized tubers of Irish potatoes with charcoal rot (Figure 3). The black discoloration was shallow. These spring-crop potatoes had been left in the hot, dry soil until July, about 7 weeks after the usual digging time. Some of the potato stems were gray or had gray spots with sclerotia of *M. phaseoli* under the gray epidermis, in the pith, and on the strands of woody tissues. Some stems were hollow. The taproots were retted and were blackened by sclerotia. Bliss Triumph stems with gray bark had typical pycnidia and spores of *M. phaseoli*. This appears to be the first report of this spore stage in the Irish potato.

Charcoal rot of potatoes in the Texas Panhandle was proved to be caused by *M. phaseoli* (18). Gray stolons containing sclerotia and shallow black rot, especially near the eyes of potato tubers, were caused by *M. phaseoli* (76). Black sunken dots one-sixteenth to one-fifth inch wide, each surrounded by a soft rotted area due to charcoal rot, were found in the peel of potato tubers that had been in hot, dry soil (48). Root rot, dry stem rot and blight were symptoms of charcoal rot of potatoes (38).

Charcoal rot is practically controlled in East Texas by planting the seed pieces about March 10 and digging the tubers about June 1 before the soil becomes hot and dry and before most of the leaves have died. Bliss Triumph and other early varieties are preferred. The tubers usually are stored under buildings. At the Tomato Laboratory near Jacksonville, potatoes from six successive spring crops were stored on dry sand under a barn, with only small loss of tubers from *Fusarium* dry rot or charcoal rot followed by bacterial soft rot (89). However, the quality of the tubers was decreased in October by potato roots in the tubers (88).

#### **Radish (*Raphanus sativus*)**

White Icicle radishes were planted in March 1948. Many plants were left in the rows to produce seed. Only a few seed stalks developed, so the roots were examined September 9. Nearly all of the fleshy radish roots were retted, hollow and nearly black with sclerotia of *M. phaseoli* (Figure 6). The black discoloration showed through the epidermis (91).

#### **Turnip (*Brassica rapa*)**

Purple Top turnips were planted in March 1948. Many plants were left in the rows to produce seeds. They were examined in

September. Many of the turnips were soft, retted and black inside with the sclerotia of *M. phaseoli* (Figure 6). One plant had seed pods and its stalk bore sclerotia under the bark. *M. phaseoli* infected turnips in artificial inoculations (45).

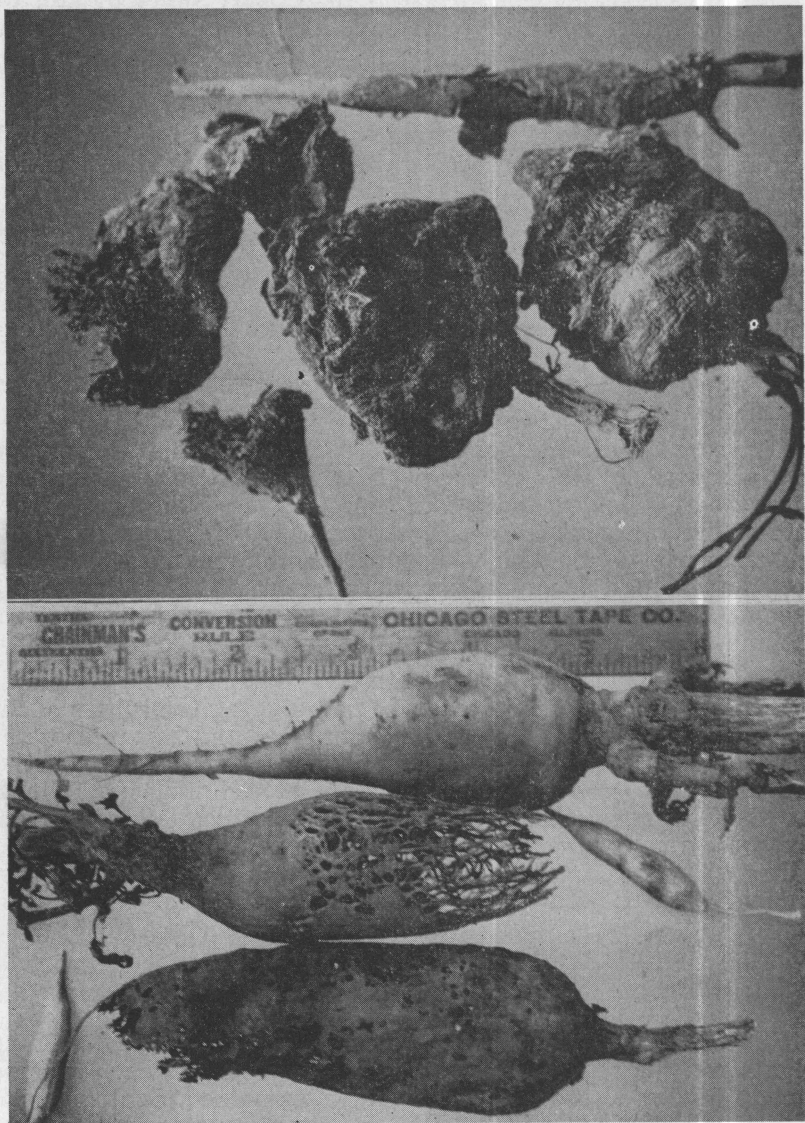


Figure 6. Top: Purple Top turnips rotted by *M. phaseoli* and blackened by its sclerotia. The upper plant had a seed stalk; the bark was torn from part of its taproot showing the tissues to be blackened with sclerotia. Bottom: Icicle radishes. The upper radish was normal. The two lower radishes were retted and hollow with only the peel and vascular system remaining; blackening was due to the numerous sclerotia of *M. phaseoli*.

**Cabbage (*Brassica oleracea* var. *capitata*)**

Cabbage was transplanted into a field in March 1948. The plants that remained in rows were examined in September. Many of these plants showed typical retting of the upper parts of the taproots and bases of the stems with blackening of the tissues with the sclerotia of *M. phaseoli* (Figure 7). Sclerotia also were deep in the woody tissues of the taproots. This appears to be the first report of charcoal rot of cabbage.

**Cantaloupe (*Cucumis melo*)**

Cantaloupe fruits had charcoal rot and were blackened with sclerotia of *M. phaseoli* (89). About 90 percent of the plants of 5 varieties of cantaloupe were killed by charcoal rot in August 1948. Most of the taproots were retted and were blackened with the sclerotia of *M. phaseoli* that occurred under the bark and in the pith and woody tissues. Charcoal rot killed many stems that were attached to live taproots. These stems were hollow, gray or brown, with abundant sclerotia in the pith cavities. Other sclerotia were on the inner side of the bark of such stems. Many cantaloupe fruits became hollow shells that were lined with dusty black sclerotia. The remaining fragments of pulp tissues were black. Two varieties of long muskmelons showed whitening of the epidermis of some stems as an additional symptom of charcoal rot. A culture of *M. phaseoli* from cantaloupe produced spores on bean stems (42).

**Watermelon (*Citrullus vulgaris*)**

About 75 percent of the Black Diamond watermelon plants in one field in September 1948 had been killed by charcoal rot. One watermelon fruit showed black rot with the inner wall of the peel blackened with sclerotia of *M. phaseoli*. There were black layers of tissues in the fruit. The main symptom was hollowing and retting of the bases of the stems and tops of the taproots that were blackened with sclerotia (Figure 8). Many sclerotia were found under the bark of watermelon crowns in 1946. One watermelon stem with charcoal rot in a field in 1946 showed typical pycnidia and spores of *M. phaseoli*. This apparently is the first report of the spore stage of this fungus in watermelon in a field.

Plants of Black Diamond watermelons resist hot, dry weather in fields in East Texas where they bear marketable fruits throughout the summers unless insects or diseases kill them.

**Pumpkin (*Cucurbita pepo*)**

Small Sugar variety of pumpkin in August 1948 showed 60 percent of its plants to be dead or dying with charcoal rot. They showed typical retting of the bases of the stems and tops of the taproots, and blackening by sclerotia under the bark and among the woody strands. Charcoal rot killed many stem branches from live taproots. A pumpkin fruit was rotted with many

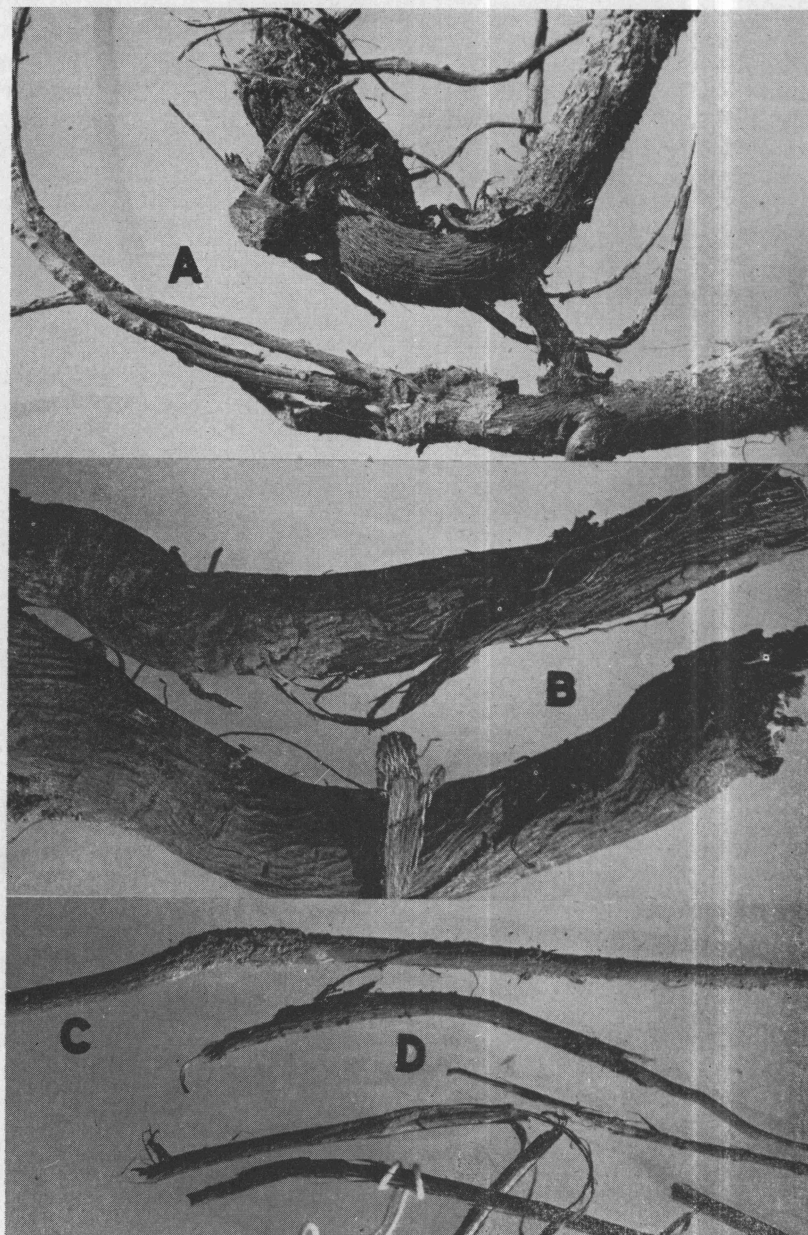


Figure 7. A: Cabbage taproot showing decomposition of bark with blackened wood below it. B: Bases of two stems of *Heterotheca subaxillaris* with charcoal rot; upper stem shows retted bark, while slice of bark was cut from lower stem. C: *Crotalaria mucronata* var. Giant Striata stem showing charcoal rot of crown tissues; sand adhered to the crown. D: Stems of *Sesbania macrocarpa* with charcoal rot.



sclerotia on the seeds, in the fleshy tissues and on the inner side of the peel (Figure 8).

**Squash (*Cucurbita maxima* and *C. pepo* var. *condensa*)**

Ninety percent of the plants of Table Queen and Yellow Crookneck varieties of squash were killed by charcoal rot in a field in August 1948. The bases of some of the stems and the upper part of nearly all of the taproots were retted, and were

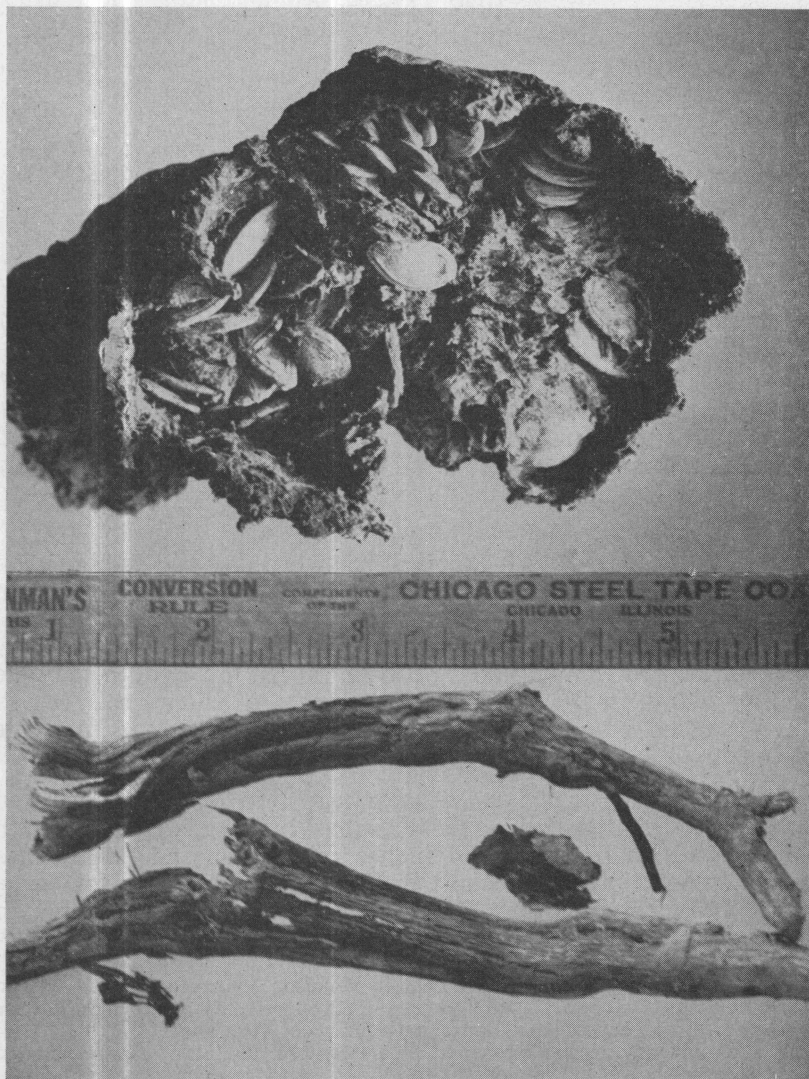


Figure 8. Top: Small Sugar variety of pumpkin rotted by *M. phaseoli* and blackened by its sclerotia. Bottom: Charcoal rot of watermelon showing retting of the bases of the stems and tops of the taproots, and blackening with sclerotia.

blackened with sclerotia on the inner side of the bark and among the woody fibers. Some stem branches were killed on live taproots. Few Table Queen fruits matured, but one of them was rotted and the fleshy tissues of the peel were black with sclerotia.

#### **Okra (*Hibiscus esculentus*)**

Sclerotia of *M. phaseoli* were found in the roots of okra (4). Charcoal rot caused extreme retting of the stems of Greenpod Okra at Jacksonville in 1947 (Figure 9). The long, loose fibers bore many sclerotia. Other sclerotia were in the hard wood of the base of the stem and top of the taproot, and on the inner side of the bark.

#### **Cotton (*Gossypium hirsutum*)**

Retting of the bark of the base of the stems and tops of the taproots so that it is easily scraped, and black sclerotia of *M. phaseoli* on the inner side of the bark and in the hard wood of the taproots characterize charcoal rot of cotton (Figure 9). The cotton plants shed their leaves as they die. These symptoms are easy to distinguish from those of Fusarium wilt and Phymatotrichum root rot of cotton (87).

Nine fields of cotton totaling nearly 250 acres in Houston county in October 1948 showed 1 to 70 percent of the plants with charcoal rot (Figure 9). Five of these fields showed 10 to 70 percent of the plants to be dead with charcoal rot as the only apparent cause. All of these fields were sandy except one field with red soil.\*

The cotton plants with charcoal rot were dug for examination and none of them showed any Fusarium wilt, Phymatotrichum root rot, nematode root-knots, or any disease except charcoal rot. The plants had been dead for several weeks before they were examined. They had not been killed by drouth, as the healthy plants in the fields still bore most of their green leaves and produced an estimated yield of one-fourth to one-half bale of cotton per acre.

Summer weather was unusually warm in 1948 and favored *M. phaseoli*. Rains totaled 4.04 inches in May, 1.11 inches in June, 0.45 inch in July, 1.74 inches in August and 1.01 inches in September 1948 at Crockett in Houston county. The total was only 3.20 inches for June, July and August which is dry enough for serious damage from charcoal rot. The correlation of char-

\*The above mentioned red-soil field in Houston county was used to test crops in 1949. October 17, 484 plants of Stoneville 2B cotton in 2 rows averaged 21 percent of the plants with charcoal rot. The D.P.L. and Half and Half cotton varieties averaged 30 percent of the plants with charcoal rot; one row showed 20 percent of the plants with charcoal rot by September 1. Pinto and Greenpod beans and Purple Hull peas showed severe charcoal rot by July 3. This summer was unusually rainy, so charcoal rot was much less abundant than last year. Charcoal rot of cotton was found September 7 in 2 fields in Madison county. At Jacksonville, none of the plants in 5.75 acres of Stoneville 2B cotton showed any charcoal rot.

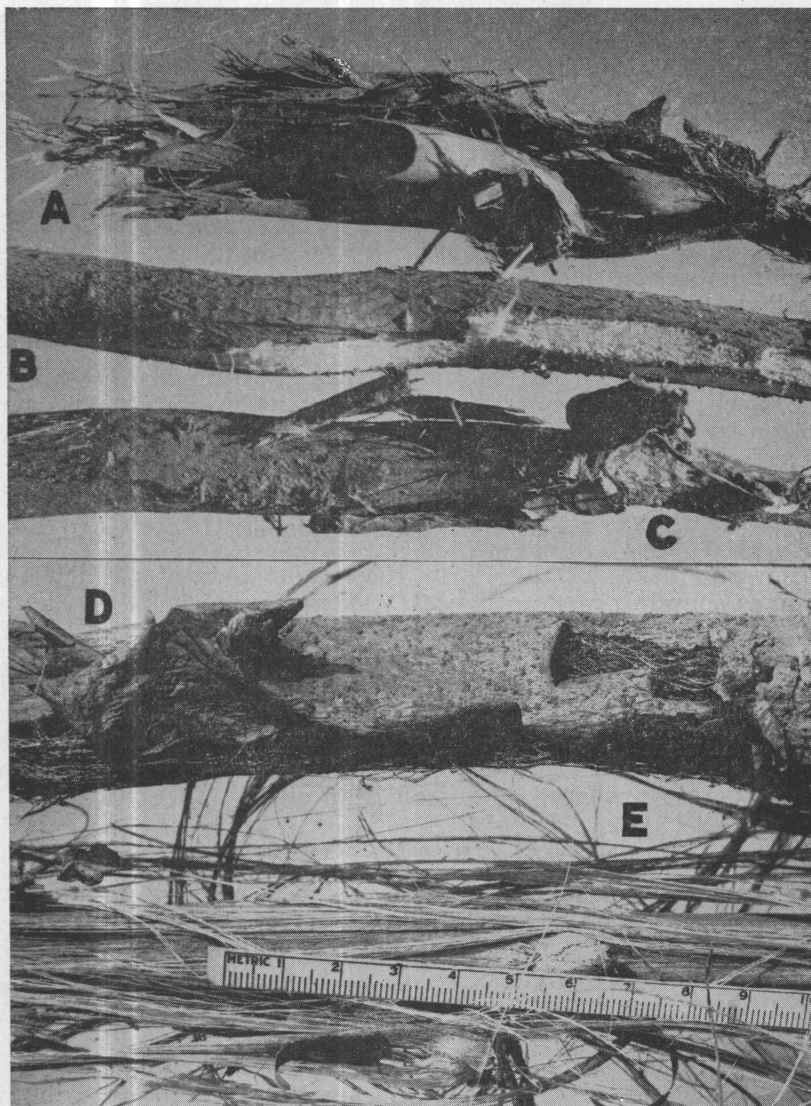


Figure 9. A and C: Tap roots and bases of stems of cotton showing retting of bark due to *M. phaseoli*; tissues were blackened by sclerotia. B: Normal taproot of cotton with the bark scraped to show the white inner tissues. D and E: Greenpod okra stems that were retted by *M. phaseoli*; tissues were blackened with sclerotia.

coal rot and rainfall may be similar for cotton and corn, as summer rainfall exceeding 10 inches is likely to minimize damage from charcoal rot. Healthy cotton is very resistant to drouth in East Texas.

Charcoal rot of cotton also was found in one field of the Del-tapine variety near College Station in October 1948. Charcoal

rot of cotton has been reported from Virginia to Georgia, and in Texas and Oklahoma (Table 2).

One variety of *M. phaseoli* was isolated from cotton that grew in Texas (24, 74). It infected legume seedlings best at 104° F. (74). Many cultures of *M. phaseoli* were different physiologic races (74).

Galloping wilt caused by *M. phaseoli* destroyed living cortical tissues of cotton (61). *Gossypium herbaceum* is very susceptible to *M. phaseoli*; this fungus probably penetrates through the phelloderm that is thinner than in *G. hirsutum*.

No charcoal rot of cotton was found in Cherokee county. This county is separated by the Davy Crockett National Forest and the Neches River from Houston county where charcoal rot of cotton was found (87). It is probable that different physiologic races or subspecies of *M. phaseoli* occur in these different counties (60, 24).

#### **Sweet Potato (*Ipomoea batatas*)**

Several plants of the Porto Rico sweet potato with hollow crowns containing sclerotia of *M. phaseoli* were found in Smith county September 1, 1948. This appears to be the second report of charcoal rot of leafy stems of sweet potato. Charcoal rot causes small loss of sweet potatoes when storage rooms are kept cool (69). The diseased tubers were black inside with drying and slight shrinkage as external symptoms. The sclerotia were oval oblong, or forked (69, 70). A culture of *M. phaseoli* from sweet potato produced spores on bean stems (42).

#### **Guayule (*Parthenium argentatum*)**

Brown sunken cankers caused by *M. phaseoli* were found near the ground level of 2-year-old guayule plants near Pearsall (56). The cankers girdled the stems and the branches died, but the roots remained alive.

#### **Heterotheca subaxillaris**

Heterotheca plants with charcoal rot were found near Jacksonville October 8, 1948. This appears to be the first report of charcoal rot of Heterotheca. The sclerotia were under the bark of the blackened taproots, and elongate sclerotia were in the hard, woody tissues of the taproots (Figure 7). Heterotheca is a common wild plant that may help to maintain *M. phaseoli* in the soil of uncultivated fields.

#### **Cosmos sulphureus**

Charcoal rot retted the base of the stems and top of the taproots of this ornamental yellow-flowered cosmos. The sclerotia of *M. phaseoli* were under the bark, in the pith and on the woody fibers.



**Zinnia spp.**

Several ornamental zinnia plants were killed by charcoal rot in 1948. The sclerotia of *M. phaseoli* were on the inner side of the bark near the base of the stems and top of the taproots, and in the hard wood of the taproots.

**HOST INDEX**

*M. phaseoli* is a soil-inhabiting fungus that causes charcoal rot in many cultivated and wild species of plants. Numerous tropical and subtropical plants are raised near the southern border of the United States and others are likely to be introduced for test or use. Foreign weeds appear on farms. Thus, it is important to know which species are likely to be damaged by charcoal rot or to maintain the causal parasite in the soil. Hence, a host index of attainable completeness is given in Table 2.

Table 2. Host plants of *Macrophomina phaseoli* (*Sclerotium bataticola*) that causes ashy stem blight and charcoal rot of plants

**Hosts with notes and references**

Abutilon theophrasti (71)  
 Acacia decurrens (60)  
 Acacia elata (60)  
 Acacia melanoxylon (60)  
 Acalypha wilkesiana (60)  
 Acer sp. in U.S. (60)  
 Albizzia sp. (60)  
 Albizzia falcata (60)  
 Albizzia moluccana (60)  
 Albizzia stipulata (60)  
 Alfalfa (Medicago sativa) in U.S. (26, 60; PDR 30:38\*\*)  
 Allium sativa (garlic)\* bulb rot (60, 64a)  
 Ambrosia artemisiifolia (common ragweed) (72a; PDR 32:117)  
 Ambrosia bidentata (72a)  
 Amherstia nobilis (60)  
 Annona muricata (60)  
 Annona squamosa (60)  
 Antirrhinum majus (60)  
 Apium graveolens (60)  
 Apple (Pyrus malus) (45, 60)  
 Apocyanum cannabinum (72a)  
 Aralia filicifolia (60)  
 Aralia japonica (60)  
 Areca catechu (60)  
 Arrenatherum PDR 27:188\*\*  
 Artocarpus integrifolia (60)  
 Asclepias syriaca (72a)  
 Asparagus\* root rot (3), (50)  
 Aster sp. (60)  
 Aucuba sp. (60)  
 Bean (Phaseolus vulgaris)\* (60; PDR 27:665; 28:861; 30:73)  
 Begonia Rex bulbosa (60)  
 Begonia tuberhybrida (60), (74)  
 Beet (Beta vulgaris) (60; PDR 30:304)  
 Bidens bipinnata (72a)  
 Bixa orellana (60)  
 Borassus flabellifer (60)  
 Brachypodium; root rot (PDR 28:1142)  
 Brassica oleracea botrytis (cauliflower) (60)  
 Brassica rapa\* (described in this article) (60)  
 Broom corn (26; PDR 29:531 and 547)  
 Buddleia variabilis (60)  
 Cabbage\* (Brassica) (described in this article)  
 Cacao (chocolate) (see Theobroma) (6)  
 Cajanus sp. (60)  
 Callistephus sp. (aster) (60)

**Hosts with notes and references**

Cantaloupe\* Muskmelon (Cucumis melo) (60, 80a; PDR 30:483)  
 Carica papaya (papaya) (60)  
 Carica quercifolia (60)  
 Cassia floribunda (60)  
 Cassia nititans (42; PDR 29:713)  
 Cassia alata PDR 29:713  
 Casuarina equisetifolia (60)  
 Catalpa sp. (26, 60)  
 Cedar (26)  
 Ceratonia siliqua (60)  
 Chamaecrista procumbens (60; 78; PDR 29:714)  
 Chamerops sp. (60)  
 Chenopodium album? (72a)  
 Chrysanthemum sp. (11; PDR 32:148)  
 Cicer arietinum (chick-pea) (60)  
 Cinchona sp. (quinine) (60)  
 Citron (Citrus vulgaris); race with hard white flesh\* (60, 89)  
 Citrus sp. in U.S. (60)  
 Citrus aurantifolia (lime) (43, 60)  
 Citrus aurantium (sour orange) (60)  
 Citrus limon (lemon) 43, 60; PDR 25:38)  
 Citrus sinensis (orange) (39, 43, 60)  
 Clitoria cajanifolia (60)  
 Clover (Trifolium sps.) red & subterranean clover (60; PDR 30:178)  
 Coffea arabica (coffee) (6, 60)  
 Coffea robusta (60)  
 Cochlearia armoracia (60)  
 Cocos nucifera (coconut palm) (60)  
 Codiaeum sp. (60)  
 Coffee weed (42)  
 Colutea arborescens (60)  
 Coriandrum sativum (coriander flavoring plant) (60)  
 Corn (Zea mays)\* (40, 60, 71; PDR 21:11; 27:558 and 612; 28:73; 29:663)  
 Coronilla glauca (60)  
 Cosmos sulphureus\* (89, 60)  
 Cotoneaster francheti (60)  
 Cotton (Gossypium hirsutum)\* (6, 10, 11, 59a, 60, 64, 67, 68, 91; PDR 27: 535, and 538 and 690; 30:222; 31:127)  
 Cotton (Gossypium barbadense); Sea Island cotton: (PDR 27:616)  
 Cotton (Gossypium herbaceum) Levant cotton (62)  
 Cowpeas (Vigna)\* (60, 91)  
 Crotalaria juncea\* (60)

\*Found in Texas.

\*\*PDR means Plant Disease Reporter.

## Hosts with notes and references

*Crotalaria intermedia*\* (42, 60, 77)  
*Crotalaria mucronata* (Giant Striata variety)\*; (described in this article)  
*Crotalaria spectabilis*\* (77, 86, 89)  
 Cucumber (*Cucumis sativus*) (45, 60; PDR 30:485)  
*Cupressus benthami* (cedar) (60)  
*Cupressus lawsoniana* (60)  
*Cupressus lindleyi* (60)  
*Cupressus macrocarpa* (60)  
*Cupressus sempervirens* (60)  
 Cypress (43)  
*Cyamopsis psoraloides* (60)  
*Cydonia oblonga* (quince) (60)  
*Cyperus distans* (sedge) (60)  
*Dahlia ashy* stem blight (60, 71; PDR 32:156)  
*Dahlia variabilis* (60)  
*Daucus carota* (carrot) (60)  
*Datura stramonium* (72a)  
*Derris elliptica* (60)  
*Dianthus barbatus* (Sweet William) (60)  
*Dianthus caryophyllus* (carnation) (60)  
*Dimorphotheca* sp. (60)  
*Diospyros kaki* (60)  
*Diospyros virginiana* (persimmon) (60)  
*Dolichos biflorus* (a genus of beans) (60)  
*Dolichos lablab* (hyacinth bean) (60)  
 Eggplant (*Solanum melongena*) (45, 60)  
*Elettaria cardamomum* (60)  
*Erigeron* (aster) (PDR 32:218)  
*Erigeron canadensis* (common mare's tail weed) (71)  
*Erigeron ramosus* (72a)  
*Eriobotrya japonica* (60)  
*Erythrina indica* (coral trees) (60)  
*Erythrina lithosperma* (60)  
*Erythrina umbrosa* (60)  
*Erythrina velutina* (60)  
*Eucalyptus globosus* (60)  
*Eucalyptus rostrata* (60)  
*Eupatorium serotinum* (72a)  
*Ficus elastica* (rubber plant) (60)  
*Ficus nitida* (60)  
 Flax (*Linum*) retted by charcoal rot (1)  
*Fagopyrum esculentum* (buckwheat) (72a)  
*Garcinia mangostana* (60)  
 Geranium sp. (60)  
*Gladiolus* sp. (60)  
*Glottidium vesicarium* (bladder pod or coffee bean)\* (89)  
 Gourds (11)  
*Grevillea robusta* (silk-oak) (60)  
 Guayule (PDR 28:984; PDR 32:284)  
*Guizotia abyssinica* (60)  
*Helianthus annuus* (sunflower) (37, 42, 43, 60; PDR 32:225)  
*Helianthus cucumerifolius* (sunflower) (60)  
*Helianthus tuberosus* (Jerusalem artichoke) (60)  
 Hemp (*Cannabis*) (71; PDR 32:420)  
*Heterotheca subaxillaris*\*; (described in this article)  
*Hevea brasiliensis* (rubber) (6, 60)  
*Hibiscus cannabinus* (fiber plant) (60)  
*Hibiscus* sp. (60)  
*Hibiscus rosa-sinensis* (Rose-of-China) (60)  
*Hibiscus sabdariffa* (a fiber plant) (60)  
*Ipomoea hederacea* (72a)  
*Ipomoea batatas* (see sweet potato) (60)  
 Iris sp. (60)  
*Jacaranda* (ornamental trees) (60)  
 Jute (2 species of *Corchorus*; (rope plant; black sclerotia in cortex; also pycnidia) (6, 60)  
*Juglans nigra* (walnut) (60)  
*Juniperus* sp. (60)  
 Kudzu (*Pueraria*) (PDR 30:131)  
*Lactuca sativa* (lettuce) (60)  
*Lactuca scariola* (42, 71; PDR 32:281)  
*Larix laricina* (seedling blight of tamarack) (15)

\*Found in Texas.

## Hosts with notes and references

*Laurus nobilis* (Sweet Bay) (60)  
*Lavandula* sp. (60)  
*Lespedeza* sp.\* (37, 42; PDR 30:8)  
*Lespedeza stipulacea* (charcoal rot) (71)  
*Ligustrum* sp. (privet) (60)  
*Lilium* sp. (60)  
*Lilium candidum* (lily) (60)  
 Lima bean\* (11; PDR 15:114; 30:69)  
*Lupinus sativus* (lupine) (60)  
 Lupines; root rot of *Lupinus* sp. (PDR 25:341; 30:11)  
*Malus mitis* (apple) (60)  
*Mamillaria* sp. (pin cushion cactus) (60)  
*Matthiola* sp. (stocks) (60)  
*Melaleuca armillaris* (ornamental bottle brush) (60)  
*Melilotus alba*\* (sweetclover) (4, 72a, 89)  
*Mentha piperata* (peppermint) (60)  
*Muconia* sp. (60)  
*Musa* sp. (banana or manila hemp) (60)  
*Musa paradisiaca* (60)  
*Muhlenbergia* sp. (leaf blight) (PDR 29:281)  
 Mung bean\* (36; PDR 28:1019; 30:67)  
*Myrtus communis* (Myrtle) (60)  
*Nemesia* sp. (60)  
*Ochroma lagopus* (60)  
*Oenothera biennis* (common weed) (72a)  
 Okra\* (60)  
*Olea europaea* (olives) (60)  
*Onobrychis sativa* (sainfoin clover) (60)  
*Panicum maximum* (60)  
*Parinarium nobola* (60)  
 Peanut\* (60; PDR 27:505; 29:368 and 690; 30:13)  
 Peas (*Pisum*) (37; PDR 30:95)  
*Pelargonium* sp. (geranium) (60)  
*Persea* (avocado) (60)  
*Persea gratissima* (60)  
 Pepper (*Capsicum*)\* (11, 43, 45, 60)  
*Phacelia tanacetifolia* (ornamental flowers) (60)  
*Phaseolus lunatus* (lima bean)\* (60)  
*Phaseolus multiflorus* (butter bean) (43, 60)  
*Phaseolus mungo radiatus* (60)  
*Phaseolus mungo* (black gram) (68)  
*Phlox* sp. (sclerotia in base of rotted stem) (72)  
*Phlox decussata* (72a)  
*Phoenix canariensis* (palm) (60)  
*Phoenix dactylifera* (date palm) (60)  
*Physalis alkekengi* (Chinese lantern) (60)  
*Physalis peruviana* (cape-gooseberry) (60)  
*Picea abies* (seedling blight of Norway spruce) (15)  
 Pidgeon pea (*Cajanus*) (6, PDR 29:711)  
*Pimpinella anisum* (anis\*) (60)  
*Pinus banksiana* (jack pine) (15)  
*Pinus ponderosa* (seedling blight of western yellow pine) (15)  
*Pinus contorta* (lodgepole pine) (60)  
*Pinus halepensis* (60)  
*Pinus maritima* (60)  
*Pinus resinosa* (seedling blight of red pine) (15)  
*Pinus sylvestris* (seedling blight of Scotch pine) (15)  
 Piper betle (Betel pepper) (60)  
*Pisum arvense* (pea) (60)  
*Pithecolobium saman* (Manila tamarind) (60)  
*Pittosporum tobira* (ornamental tree) (60)  
*Pittosporum undulatum* (Victorian box) (60)  
*Poinciana regia* (ornamental shrub) (60)  
*Polygonatum lapathifolium* (72a)  
*Populus* sp. (poplar) (60)  
 Potato (*Solanum*) (6, 7, 41, 60, 76; PDR 11:75)\*  
*Prunus amygdalus* (60)  
*Prunus armeniaca* (apricot) (60)  
*Prunus avium* (sweet cherry) (60)  
*Prunus divaricata* (myrobalan plum) (60)  
*Prunus domestica* (plum) (60)

## Hosts with notes and references

*Prunus mahaleb* (60)  
*Prunus persica* (peach) (60)  
*Pseudotsuga taxifolia* (seedling blight of Douglas fir) (15)  
 Pumpkin\* (8, 50; PDR 30:488 & 489)  
*Pyrethrum cinerariifolium* (chrysanthemum) (60)  
*Pyrus communis* (pear) (60)  
 Radish\* (60)  
*Rheum undulatum* (60)  
*Ribes* sp. (gooseberry) (60)  
*Ricinus communis* (castor bean) (60)  
 Rose (*Rosa* sp.) 43, 60)  
*Rosmarinus* sp. (60)  
*Rudbeckia hirta* (72a)  
*Rumex* sp. (dock) (60)  
*Russelia officinarum* (60)  
*Santalum album* (60)  
*Santolina* sp. (60)  
*Salvia* sp. (sage) (PDR 32:413)  
*Scabiosa* sp. (ornamental flower) (60)  
 Sesame (*Sesamum*)\* (wilt, root rot, ashly stem blight) (4, 6, 60, 68, PDR 32:486)  
*Sesbania macrocarpa*\* (described in this article)  
*Sesbania punctata* (60)  
*Setaria lutescens* (72a)  
*Sida spinosa* (common weed related to cotton) (72a)  
*Solanum carolinense* (72a)  
*Sorghum annuum* (60)  
 Sorghum\* (40, PDR 27:532 and 29:545)  
*Solidago altissima* (goldenrod) (72a)

\*Found in Texas.

## Hosts with notes and references

Soybean\* (60, PDR 27:509; 28:687; 30; 134)  
 Squash\*  
 Strawberry (43, 60, 74)  
*Stizolobium deeringanum* (velvet bean)\* (60)  
*Strophostyles* (*Phaseolus*?) *helvola* PDR 23:138, 30:136)  
*Styrax* sp. (60)  
 Sugar beet (37, 60, 74)  
 Sugar cane (60)  
 Sweetclover—(see *Melilotus*)  
 Sweet Sudan grass\* (4, PDR 29:546)  
 Sweet potato (*Ipomoea*)\* (11, 45, 69; PDR 27:713; 29:346; 30:356)  
*Tagetes erecta* (marigold) (60)  
*Tagetes* sp. (marigold) (57, PDR 32:329)  
 Tea (*Thea* sp.) (6, 60)  
*Tephrosia candida* (60)  
*Theobroma cacao* (chocolate) (60)  
*Thuja* sp. (*arbor vitae*) (60)  
 Tobacco (43, 60; PDR 18:117)  
 Tomato\* (43, 60, 89)  
*Tristana conferta* (60)  
 Triticum sp. (wheat) (60)  
 Turnip\*; see *Brassica*  
*Verbascum* sp. (mullein) (60)  
*Verbena hortensis* (PDR 33:108)  
*Vicia faba* (broad bean) (60)  
*Vicia sativa* (vetch) (60)  
*Viola odorata* (60)  
*Vitis vinifera* (grape) (60)  
 Watermelon\* (11, 89; PDR 30:480)  
*Zinnia elegans*\* (60; PDR 32:335)

## METHODS OF CONTROLLING CHARCOAL ROT

Methods of invigorating crop plants are likely to give increased yields despite some damage by charcoal rot. Abundant moisture from rain or irrigation water in the latter part of the growing season practically controls the stem-rot form of charcoal rot (29, 41, 51). Late varieties of sorghum that ripen in cool, rainy weather are likely to escape serious damage from charcoal rot (32). Sorghum and other crops appear to resist charcoal rot in their grand period of growth when they have maximum vitality.

Crop plants range from very susceptible to immune to charcoal rot (91). Thick-stalked, leafy varieties of sorghum are damaged least by charcoal rot (19). Promising resistance was found in some varieties of sorghum (27). Table 1 shows promising resistance to charcoal rot in some varieties of corn. Iron, California Blackeye No. 1 and the related Blackeye No. 8152 varieties of cowpeas resist *M. phaseoli* (44, 85, 91). Giant Striated crotalaria was almost immune to charcoal rot in 1948.

### SUMMARY

1. *Macrophomina phaseoli* (*Sclerotium bataticola* and *Rhizoctonia bataticola* are often-used synonyms) causes charcoal rot in at least 284 species of plants that are listed in Table 2. Charcoal rot damages corn, sorghum, cowpeas, beans, turnips, *Crotalaria*, peppers, potatoes, sweet potatoes and melons in many parts of Texas. Charcoal rot of cotton was found in only three counties of Texas. The symptoms of charcoal rot are described for many farm crops in Texas.

2. The most common symptom of charcoal rot is shredding of the tissues of the base of the stems and tops of the taproots that are blackened with sclerotia. Twelve of the host plants showed gray discoloration of the stem bark as one symptom. Seven hosts had fruits rotted by charcoal rot. Seedling blight due to charcoal rot was reported only in sorghum, corn and beans. Pycnidia and spores of *M. phaseoli* were found in six hosts.

3. This is apparently the first description of charcoal rot of cabbage, *Heterotheca*, *Sesbania macrocarpa*, and *Crotalaria mucronata*. Apparently this is the first report of the pycnidia and spores of *M. phaseoli* in the stems of the watermelon and Irish potato.

4. Severity of charcoal rot of corn was correlated with the total rainfall in June, July and August. Charcoal rot was mild in the two years with rainfall exceeding 19 inches in these 3 months, and was severe in the 4 years when rainfall totaled only 3 to 6 inches in these 3 months.

5. Crops that have their seedling stages and those that mature in cool or rainy weather are not damaged seriously by charcoal rot. Methods of crop production that invigorate the plants apparently increase their resistance to charcoal rot. Resistant varieties of some crops help to control charcoal rot. This disease is controlled practically by enough rain or irrigation water in the latter part of the growing season.

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